III. "On Slow Changes in the Magnetic Permeability of Iron." By William M. Mordey. Communicated by Professor Silvanus P. Thompson, F.R.S. Received December 19, 1894.

When iron is magnetised for a long time by rapidly alternating currents, its magnetic permeability is usually reduced, a gradual increase taking place in the amount of energy absorbed in producing a given magnetisation. This effect has been observed in connection with the working of transformers on alternate-current systems. Although it has been known for some time to a few electrical engineers, the author is not aware that any investigation or proof has been published as to the cause of this change.*

When the author first became aware of this increase he investigated the subject in connection with the work of the Brush Electrical Engineering Company, and to that company acknowledgments are due for permission to publish the results so far obtained. It may be mentioned that the investigation is still in progress.

In the first place explanations were sought in direct connection with the magnetic or electric actions that take place.

The explanation that first suggested itself was that eddy currents were being set up in the coils by leakage or partial failure of the insulation between adjacent portions of the conductor, or that eddy currents were being set up to an increased degree in the iron by disturbance or change of the insulating material interposed between the thin plates of iron of which the transformers were composed.

* The following are the only published references to this subject, so far as known to the author:—

In the 'Electrician' of December 7th, 1894, the subject is introduced by Mr. G. W. Partridge, with some examples of the increase and a statement that the effect is due to a "molecular change or fatigue in the iron."

There is also a note by Professor Ewing referring to Mr. Partridge's article, also ascribing the effect, if confirmed, to "a progressive magnetic fatigue."

In the same journal for December 14th, 1894, there is an article on the subject by Dr. Fleming, stating that the effect is not general, that he has failed to find it in some cases, and pointing out that differences of temperature at the times of testing may account for the variations observed.

Mr. R. T. Smith states that in one sample of iron he has found considerable increase after about 240,000,000 reversals.

Mr. O. T. Blathy, of Buda-Pesth, states that he is familiar with the effect, that the loss in magnetising transformers increases from 20 to 25 per cent., and that artificial heating of the transformer for several hours to about 150° C. will have the same effect, which he states is permanent.

Sir David Salomons also states that he has referred to the effect in a work written some months ago.

A careful examination showed that this explanation was untenable. The increase was found in transformers, the coils of which were thoroughly dry and well insulated, and in which no change had occurred in the separating material between the plates. This was confirmed by removing the iron and trying it with new coils specially insulated—also by trying the old coils with other samples of iron which had been separately tested.

Another explanation suggested was that the effect was a sort of magnetic fatigue—that the iron deteriorated somewhat in the same way as with steel springs, which suffer from "fatigue" after a great number of extensions or vibrations.

The gradual increase in the energy absorbed pointed to a physical change in the iron, which behaved exactly as if it slowly hardened and so became less permeable—as if the softening results of the process of annealing were being gradually lost.

Effect of Annealing.—On carefully re-annealing some of the iron by heating it to redness and cooling slowly, it entirely recovered its original high permeability.

Having thus found that the iron was not permanently or irremediably affected—although apart from annealing the effect seems to be permanent—it remained to ascertain whether the change was due directly to the magnetic action, or whether it was caused by some secondary condition, having the reversals of magnetism as a primary cause.

Effect of Heat.—An investigation was therefore made as to the effect of heat on the iron.

Under the conditions of working, the temperature of the iron in transformers is raised, both by the energy dissipated in the iron itself by hysteresis and eddy currents, and also by conduction and radiation from the copper windings forming the primary and secondary conductors. This rise of temperature varies according to the conditions of working and the construction of the transformer; usually it is from 20° to 60° C. above the surrounding atmosphere.

In order to investigate the action of heat, as distinct from magnetic or electric action, some samples of iron were kept for some months in an oven maintained at temperatures varying from about 60° C. to about 75° C. These samples were of iron obtained for transformer construction and were built up in the manner of transformers, having windings which were used simply for testing purposes.

Method of Measuring.—The coils used were of known turns and resistance. The wire was of such a size as to make the C^2R loss negligible in comparison with the losses in the iron. The power was measured by a very sensitive wattmeter, constructed by Dr. Fleming, the volts by a Cardew voltmeter checked against a Kelvin multicellular electrostatic voltmeter, and the current by a

Siemens electro-dynamometer. These were instruments in regular use for manufacturing purposes and used in fixed positions. The readings of watts and volts are reliable within about 0·5 per cent. The current readings are less accurate, as the range of the instrument was not very suitable. The source of current was a 37-kilowatt alternator of the author's type, working at 100 periods per second, and at a high E.M.F. The low E.M.F. required for the tests, from 20 to 60 volts, was given by the secondary of a transformer, the primary of which was connected to the alternator. Variations of E.M.F. were obtained by adjustment of the field excitation of the alternator.

There are irregularities in the tabulated readings which are probably not entirely due to errors of observation, but to differences of the conditions under which the tests were made. For example, the iron when removed from the oven was allowed to cool, but the exact temperature was not taken, and it certainly was not the same in all cases. In August it would probably be higher than in December. And although the alternator used to supply the testing current was the same in all cases and was run at the same periodicity, there were differences of condition of the circuit and load which may have had a slight influence on the results.

Sample No. 1. This consisted of a block built up of stampings arranged as in Fig. 1, which shows section and plan, the outside dimensions of the plates being $16\frac{1}{2}$ ins. by 11 ins. The sheets were 0·014 in. (0·354 mm.) thick, varying slightly; they were built up to a certain thickness with 100 stampings separated by paper, the total weight being about 55 lbs. The winding is shown at C.

Samples Nos. 2 and 3 were made up exactly the same as No. 1, but were taken from different supplies of iron.

They were occasionally removed from the oven, allowed to cool, and then returned to the oven after a test had been taken of the loss of energy with a given magnetisation.

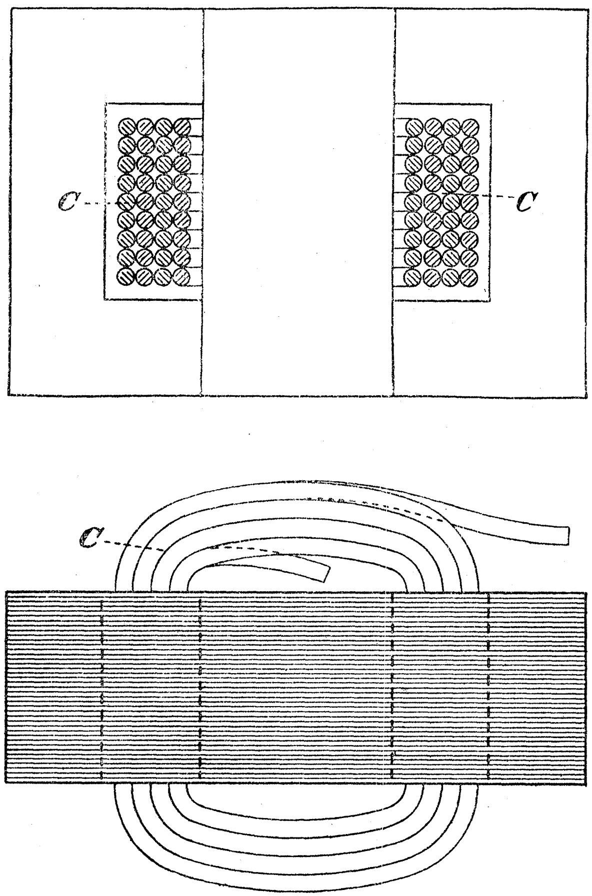
The results obtained from these three samples are given respectively in Tables 1, 2, and 3, and graphically in Diagrams 1, 2, and 3. For ease of comparison the watts are plotted as percentages in all the diagrams.

The magnetising coil in each of these cases consisted of 100 turns of copper strip 0·16 in. by 0·09 in., having a resistance of 0·15 ohm, or so low as to make the C^2R loss negligible, as compared with the loss in the iron. For example: with the maximum current used, 0·7 ampère, $C^2R = 0·0735$ watt, the total loss being 29·3 watts.

In the foregoing examples the iron magnetic circuit is not quite continuous: it is interrupted in part by butt joints and in part by lap joints.

Sample No. 5. In order to eliminate any errors that might con-

Fig. 1.

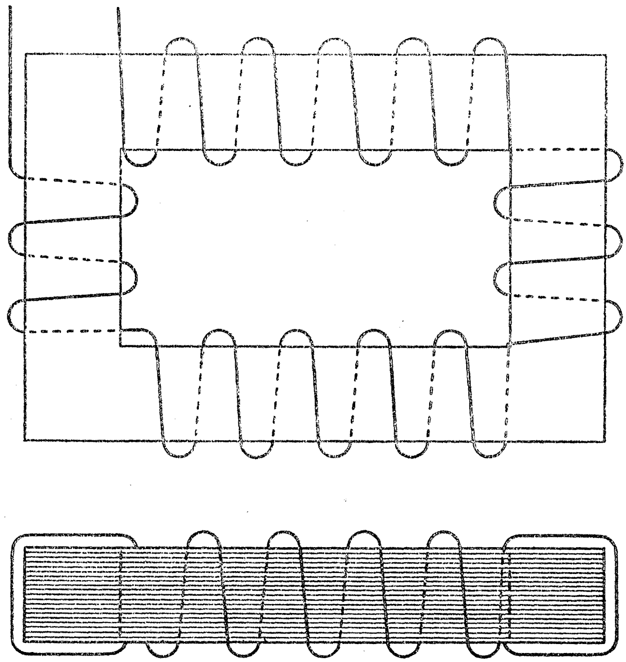


ceivably be caused by alterations at the joints, a rectangle was made up as follows:—

A number of iron plates were taken, each $16\frac{1}{2}$ ins. by 11 ins. by 0·014 in., there being stamped out from the middle of each plate a piece 11 ins. by $5\frac{1}{2}$ ins., as in Fig. 2, showing side and edge views. The plates were separated by paper and bound together by tape. They were then overwound, as in the figure, with a continuous winding, consisting of 140 turns of insulated copper wire 0·049 in. diameter (resistance 0·4 ohm) so disposed as to magnetise the block almost evenly throughout the magnetic circuit.

The measurements made with this sample are given in Table V and Diagram 5.

Fig. 2.



On the occasion of each test, measurements were made at three densities, viz., **B** 2500, 2752, 3050.

The sample was kept in the oven between each set of tests, at the same temperature as the others, that is, an average of about 67° C.

It will be seen that the hysteresis is still rising, the change being about in the same order as in the other samples, showing that the question of joints has no noticeable effect. The change also follows closely the same order, whether measured at 2500, 2762, or 3050 **B**.

Effect of Pressure.—An attempt was made to find if the increase was due directly to heat or to a mechanical condition brought about by the heat.

A possible explanation of the increase of hysteresis suggested itself in connection with the method of construction. In transformers the iron laminæ are usually bolted together very firmly, in order to ensure good contacts at the magnetic joints, to prevent noise, and for ordinary purposes of mechanical construction. It appeared possible that the expansion of the iron, due to heat, caused the plates to be pressed together more firmly when hot than when cold, and that this state of compression, if long continued, had a hardening effect on the iron similar to that caused by cold rolling or hammering.

One objection to this explanation was, that as the iron bolts holding the plates together were heated nearly as much as the plates, and therefore expanded nearly as much, the pressure could only vary slightly.

It was thought that in some forms such a gradual hardening might also be caused by the pressure exerted by the weight of the upper plates on the lower ones. But the increase was found where there was no superincumbent weight, in transformers in which the plates rested on their sides or edges.

In order to investigate this point two experiments were tried. The first was with the sample marked No. 5. In order, as far as possible, to avoid any compression, the plates in this sample were not bolted or clamped together, but, as described above, were merely held together by a binding of insulating tape and by the layer of copper wire with which they were covered. The results given in Table V do not differ materially from those of Nos. 1, 2, and 3.

An observation which tends to indicate that pressure is not the cause of the change of condition was made some time ago. Different parts of the iron of a transformer, which had been in use some time, were examined, when it was found that the middle portions were rather more affected than the end portions. As the end portions, being most exposed, are least heated, and as in this instance all parts were subject to the same amount of pressure by the clamps or bolts, this observation does not support the supposition that pressure is the cause of the change. As, however, commercial iron varies in its hysteresis, even in the same sheet, the observation is of doubtful value

A second set of tests is that marked No. 6. In this case the iron used was of the same size as in Nos. 1, 2, and 3, but of smaller amount.

It was arranged with a testing coil in the same manner, but instead of keeping the iron with its coil complete throughout the experiment, the coil was only put on for the tests, and was then removed, the iron being placed in the oven, arranged as a flat block (its upper surface being about 150 sq. ins.), with a weight of about 300 lbs. on it till the next test was made. It was thought that perhaps the slight pressure produced in this way might affect the results. These are given in Table VI and Diagram No. 6, and are markedly different from the tests of Nos. 1, 2, 3, and 5. The increase of hysteresis is greater, although the test has not been so long in progress.

This point deserves full investigation, and the author hopes to obtain further results from tests now in progress.*

Change of Power-factor.—The power-factor or ratio of watts to volts × ampères shows an irregular increase in all the tests. This

* See Appendix I, p. 240.

increase in the power-factor indicates a possible (but improbable) increase in the eddies, such as would be accounted for by a decrease of the specific resistance of the iron. The author is proceeding to investigate this matter by continuously heating a ring formed by winding a volute of iron ribbon or wire, overwound with a testing coil of copper wire. The ends of the iron being brought out enable measurements of the resistance to be taken, the magnetising losses being measured as in the other samples.*

Magnetisation not necessary to Production of the Effect.—Having ascertained that neither magnetic nor electric action was necessary to the production of this effect, the author has endeavoured to find whether alternate-current magnetisation of iron can be carried on continuously, or for considerable periods, without producing any noticeable change, and, although the evidence is not sufficient to justify a positive statement, he finds that so long as the iron is kept cool it suffers no reduction of permeability. For example, a transformer in regular use for certain testing purposes, and used several hours daily during the last fifteen months, has kept its permeability unaltered. It is magnetised at various densities up to about 2700 **B**. It is a specially designed apparatus, of large size for the work it has to do (and therefore inefficient and costly), and the temperature of its iron probably never rises more than about 6° to 8° C. above the room in which it is placed. It may be that its daily periods of rest account for the absence of change. This supposition is, however, not supported by other cases where iron which has been in regular use, but with daily periods of rest, has shown the increase of hysteresis very clearly.

Condition not Changed by Repose.—Further, the iron of some transformers which showed this increase, but which for several months have not been used, shows no return to the original condition. The author is therefore inclined to believe that if periods of repose in some cases prevent the rise, it is because the time of use is not long enough to allow of much increase of temperature.

This part of the subject is being pursued, but for the present the author will only say that, so long as iron is only slightly warmed (even when that warmth is caused by alternate-current magnetisation) its permeability remains unaffected.

It may be that repose at a temperature near or below zero, Centigrade, or at a still lower temperature, would have some effect. It appears possible, since continued expansion due to moderate heat can bring about this permanent increase of hysteresis, that continued contraction by moderate cold may bring the iron back to its original condition, or even permanently increase its permeability. The author intends to investigate this point.

* See Appendix II, p. 241.

The slow increase of hysteresis,* which is the subject of this communication, must not be classed with the immediate effect produced by the moderate heating of iron. When the iron of transformers is heated, in working, it at first absorbs less energy than when cool, probably because the increase in its resistance lessens the eddies set up in it. This is the case whether the heating is by ordinary means or by magnetic reversals. It is a temporary effect—the loss goes up again on cooling. If it is kept heated, a slow change takes place, the loss gradually increasing again, from the decrease of permeability caused by heat.† If the temporary reduction of the loss is entirely accounted for by the increased resistance reducing the eddies, it appears to afford a means of separating the losses caused by hysteresis proper, and those caused by eddies. The ordinary measurement of magnetising loss of course gives the sum of these two.

The increase of hysteresis shown in the tests, and resulting from the heating, is somewhat greater than the author has observed in transformers where the heat has been caused by the magnetic and electric losses; possibly this is because in the latter cases the temperature has been somewhat lower.

All the tests show an increase of loss, the maximum apparently not yet having been reached. The tests are being continued.

Conclusions.—The conclusions to which these observations lead, so far as they have gone, are:—

1. The effect is not fatigue of the iron caused directly by repeated magnetic reversals—it is not "progressive magnetic fatigue."

2. Neither magnetic nor electric action is necessary to its production.

3. It is a physical change resulting from long-continued heating at a very moderate temperature.

4. It appears to be greater if pressure is applied during heating.

5. It is not produced when the iron is not allowed to rise more than a few degrees above the ordinary atmosphere.

6. It is similar to the effect produced by hammering, rolling, or by heating to redness and cooling quickly.

7. The iron returns to its original condition on re-annealing.

8. It does not return to its original condition if kept unused and at ordinary atmospheric temperatures, whether the periods of rest are short or long.

* This effect may have an important influence on the reliability of measuring instruments having iron portions magnetised by alternate currents. The constants of such instruments may gradually fall.

† See Appendix III, p. 242.

Table I (see also Diagram 1).

Magnetisation = 2500 **B**. Section of Iron, 49·7 sq. cm.

	Ampères.	Power-factor.	Watts.	Date.		
	0·41	0·74	16·54	August	24,	1894.
	0·50	0·75	20·76	September	20,	,,
	0·53	0·87	25·65	,,	27,	,,
	0·54	0·88	26·6	October	5,	,,
	0·56	0·83	25·71	,,	12,	,,
	0·58	0·85	26·9	,,	23,	,,
	0·59	0·89	28·77	,,	29,	,,
	0·60	0·81	26·71	November	5,	,,
	0·60	0·84	27·4	,,	13,	,,
	0·59	0·82	26·31	December	6,	,,
	0·61	0·85	28·88	,,	12,	,,
*	0·62	0·85	29·03	,,	27,	,,
*	0·61	0·81	27·9	January	7,	1895.
*	0·62	0·81	27·3	,,	25,	,,
*	0·62	0·85	28·96	February	7,	,,

* Added since diagram was engraved.

DIAGRAM 1.

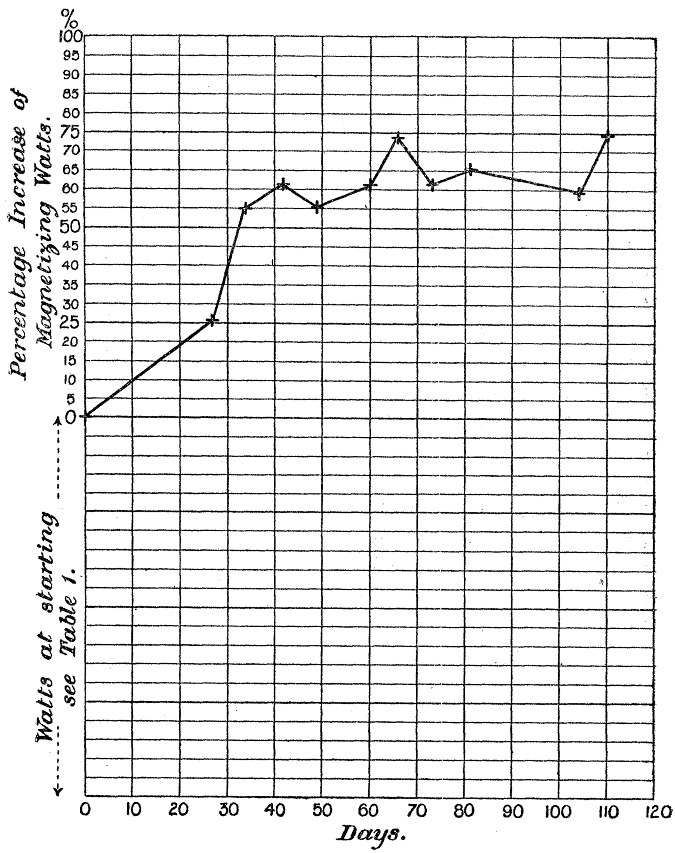

%
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
Percentage Increase of Magnetizing Watts.
Watts at starting see Table 1.
0
10
20
30
40
50
60
70
80
90
100
110
120
Days.

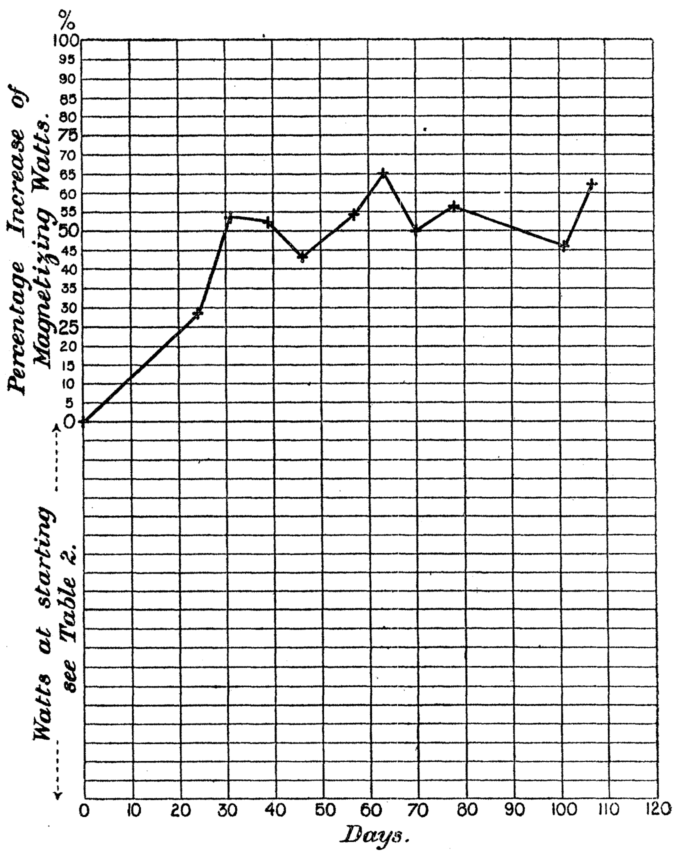
Table II (see also Diagram 2).

Magnetisation = 2500 **B**. Section of Iron, 49·7 sq. cm.

Ampères.	Power-factor.	Watts.	Date.
0·55	0·7	20·12	August 27, 1894.
0·66	0·71	25·8	September, 20, ,,
0·66	0·84	30·75	,, 27, ,,
0·67	0·86	30·55	October 5, ,,
0·71	0·75	28·79	,, 12, ,,
0·70	0·8	30·99	,, 23, ,,
0·71	0·85	33·08	,, 29, ,,
0·71	0·8	30·05	November 5, ,,
0·714	0·8	31·46	,, 13, ,,
0·7	0·79	29·3	December 6, ,,
0·74	0·745	32·54	,, 12, ,,
* 0·72	0·87	34·7	,, 27, ,,
* 0·73	0·77	30·85	January 7, 1895.
* 0·74	0·75	30·8	,, 25, ,,
* 0·74	0·8	32·87	February 7, ,,

* Added since diagram was engraved.

DIAGRAM 2.


%
100
95
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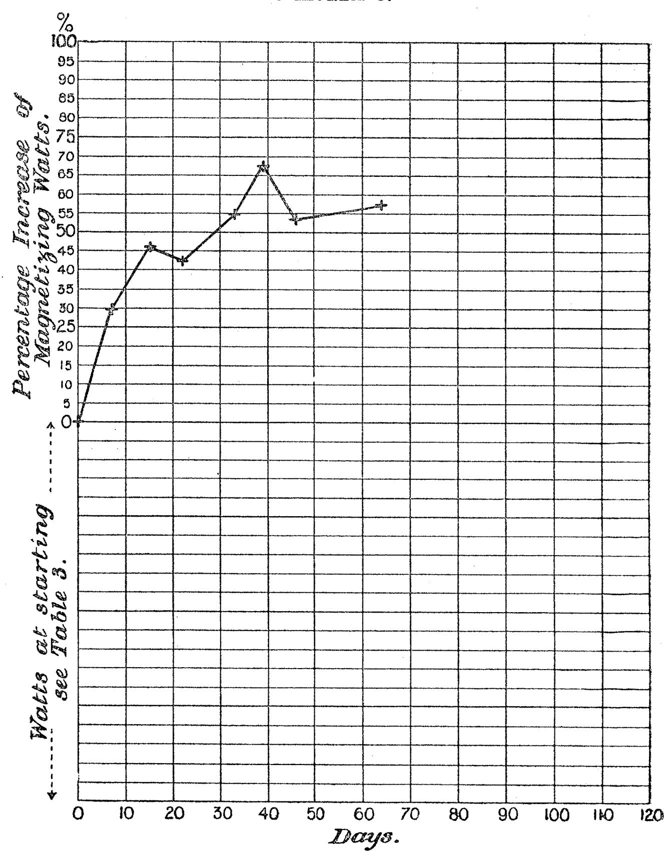
60
55
50
45
40
35
30
25
20
15
10
5
0
Percentage Increase of Magnetizing Watts.
Watts at starting see Table 2.
0 10 20 30 40 50 60 70 80 90 100 110 120
Days.

Table III (see also Diagram 3).

Magnetisation = 2500 **B**. Section of iron, 49·7 sq. cm.

Ampères.	Power-factor.	Watts.	Date.
0·43	0·7	16·61	September 20, 1894.
0·46	0·8	21·5	,, 27, ,,
0·51	0·86	24·28	October 5, ,,
0·53	0·8	23·7	,, 12, ,,
0·55	0·84	25·61	,, 23, ,,
0·56	0·89	27·67	,, 29, ,,
0·56	0·82	25·4	November 5, ,,
0·55	0·8	26·16	,, 13, ,,
Coil short circuited		..	December 6, ,,

DIAGRAM 3.



This sample was then removed from the oven and left in repose. It was again tested on January 25, 1895, with the following result:—

Loss at 2500 **B**, 25·4 watts, showing that repose for fifty days had produced no effect.

Table V (see also Diagram 5).

Ampères.	Power-factor.	Watts.	B.	Date.
0·46	0·76	8·9	2500	
0·48	0·85	10·3	2762	September 29, 1894.
0·50	0·86	12·1	3050	
0·46	0·83	8·81	2500	
0·48	0·8	9·91	2762	October 5, ,,
0·51	0·84	12·08	3050	
0·49	0·79	8·85	2500	
0·51	0·78	80·18	2762	,, 12, ,,
0·53	0·81	12·18	3050	
0·56	0·86	11·15	2500	
0·59	0·86	12·82	2762	,, 23, ,,
0·61	0·87	14·79	3050	
0·58	0·88	11·73	2630	
0·60	0·9	14·9	2762	,, 29, ,,
0·61	0·92	15·94	3050	
0·60	0·88	12·13	2500	
0·61	0·9	14·22	2762	November 5, ,,
0·64	0·87	15·67	3050	
0·60	0·9	12·35	2500	
0·62	0·91	14·5	2762	,, 13, ,,
0·65	0·88	16·18	3050	
0·65	0·87	13·1	2500	
0·69	0·88	15·5	2762	December 6, ,,
0·71	0·88	17·68	3050	
0·67	0·9	14·28	2500	
0·70	0·95	16·96	2762	,, 12, ,,
0·72	0·92	18·76	3050	
* 0·64	0·9	13·83	2500	
0·67	0·9	15·74	2762	,, 27, ,,
0·71	0·9	18·37	3050	
0·67	0·82	12·7	2500	
0·69	0·86	15·1	2762	January 7, 1895.
0·72	0·84	17·0	3050	

* Added since diagram was engraved.

Table V—*continued.*

	Ampères.	Power-factor.	Watts.	B.	Date.
*	0·67	0·83	12·9	2500	January 25, 1895.
	0·71	0·81	14·64	2762	
	0·74	0·81	16·82	3050	
	0·69	0·87	13·9	2500	February 7, „
	0·72	0·87	16·0	2762	
	0·74	0·88	18·4	3050	

Diagram 5.

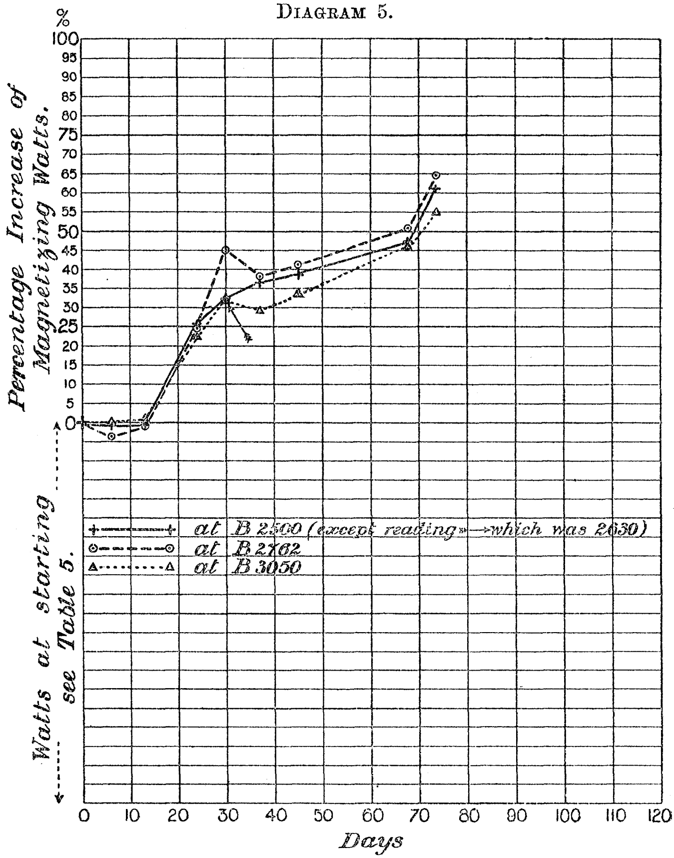


Table VI (see also Diagram 6).

Magnetisation = 2500 **B**.

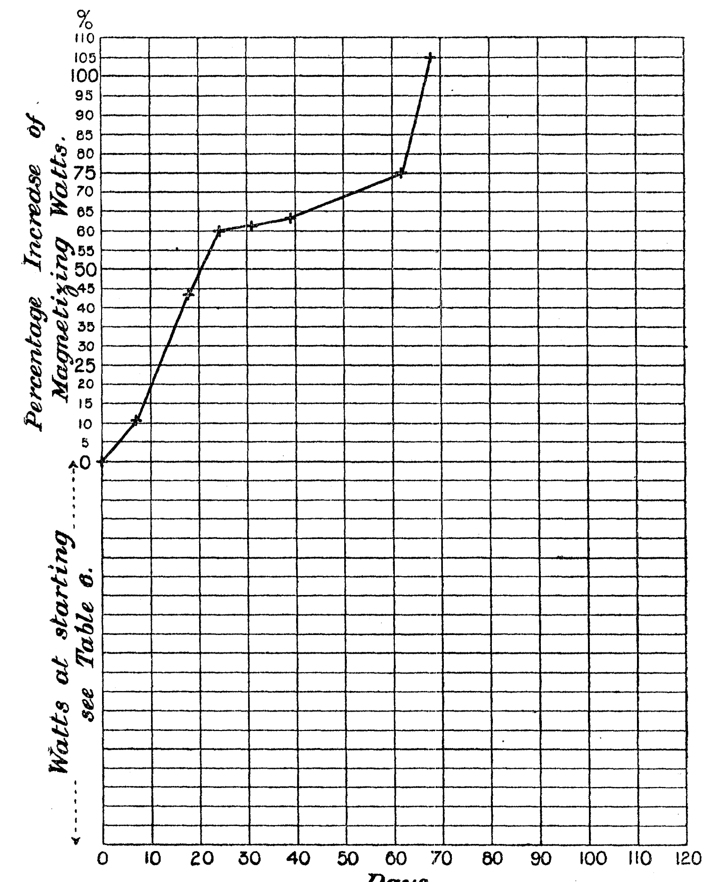
Ampères.	Power-factor.	Watts.	Date.
0·37	0·71	7·25	October 5, 1894.
0·38	0·77	7·99	„ 12, „

* Added since diagram was engraved.

Table VI—*continued.*

	Ampères.	Power-factor.	Watts.	Date.		
	0·46	0·8	10·33	October	23,	1894.
	0·46	0·9	11·55	„	29,	„
	0·50	0·84	11·61	November	5,	„
	0·59	0·85	11·8	„	13,	„
	0·55	0·82	12·63	December	6,	„
	0·56	0·94	14·8	„	12,	„
*	0·596	0·86	14·2	„	27,	„
*	0·586	0·80	13·0	January	7,	1895.
*	0·61	0·76	12·65	„	25,	„
*	0·616	0·82	13·9	February	7,	„

Diagram 6.



* Added since diagram was engraved.

Added February 9, 1895.

Appendix I.

Effect of Pressure without Heat.—The following test on the effect of pressure has been made without the application of heat. A transformer constructed in the manner of Fig. 1 was taken and tightened up by hand in the usual way, sufficient for ordinary purposes of construction. The loss, on magnetising to 2180 **B** at 100 ∼ was found to be 59·8 watts.

It was then submitted to a pressure of 100 tons, or about 1500 lbs. per sq. in. (10·57 kilos. per sq. cm.), in a direction to force the laminæ closer together, the tightening bolts then being screwed up with the pressure on. On magnetising again to 2180 **B** the loss was found to be 72·5 watts, or an increase of 21 per cent.

It was kept bolted up in this way for 30 days, and readings taken occasionally as shown in Table IV, the loss remaining practically unchanged under this continued application of pressure.

The bolts were then slackened and the loss, on being again measured, was found to be the same as before the pressure was applied.

Thus, without heat, pressure (up to the limits of the test) produces no permanent effect. But that even a very small pressure will increase the permanent effect of heat is shown by the results given in Table VI.

It should, however, be remembered that Table VI is the record of only a single set of tests, and that it is not known what the effect would have been if the iron had been heated without any application of pressure. It is, therefore, safe only to say that under considerable pressure, without the application of heat, there is a change of a definite amount which remains constant under constant pressure, and which disappears immediately on the removal of the pressure.*

It is, however, clear that the slow decrease in permeability under continued moderate heating is not to be accounted for by hardening produced by pressure.

The hardening, which takes place very slowly at these low temperatures, is similar, apparently, to the hardening which takes place when iron is heated to a high temperature and then suddenly cooled.

* Experiments on a solid bar under pressure have been made by Ewing and Low. "On the Influence of a Plane of Transverse Section on the Magnetic Permeability of an Iron Bar," 'Phil. Mag.,' September, 1888.

Table IV.

(Without application of heat; magnetised only for a few minutes occasionally for purpose of measuring loss.)

	Watts.
Before applying pressure......	59·8
During application of pressure of 1500 lbs. per sq. in. (10·57 kilos. per sq. cm.)	72·5 on application. 70·2 after 9 days. 72·2 ,, 22 ,, 70·2 ,, 30 ,,
Without pressure	59·4 on 30th day.

The author has a test in hand to find the effect of heat combined with considerable pressure, but cannot yet give any results.

Appendix II.

The results obtained in this way, so far as the investigation has gone, are as follows :—

A ring was made up of iron ribbon, wound in a close volute, the convolutions separated from each other by paper. This was then wound with a magnetising winding of copper wire covering the whole ring. A test was taken on January 15, 1895, of the resistance of the iron, and of the energy spent in magnetising it to 2500 **B** at 100 $\sim$. It was then kept in an oven at a temperature ranging between 60° and 75° C. It was taken out, cooled, and the tests repeated on January 25 and February 8 as below :—

Date.	Temperature.	Watts at 100 $\sim$.	Power-factor.	Resistance of the iron.
	C°.			
January 15..........	17·3	4·9	0·72	0·94[10]
,, 25..........	17·0	5·4	0·73	0·96
February 8..........	17·3	6·7	0·8	1·07

Thus the hysteresis loss has gone up considerably, as a result of continued heating, and the resistance has also risen. This result is in accordance with what is known as to the connection between the magnetic permeability and the electrical resistance of iron. Professor Hughes showed many years ago* that the lower the resistance of iron the better its magnetic qualities.

As bearing on this point, the author has measured the resistance of some soft annealed iron strips, which were then hardened by being

* 'Roy. Soc. Proc.,' December, 1883.

heated to redness and quenched in oil at 14° C. It was found that this hardening process increased the resistance 4 per cent. and 7 per cent. in different samples.

APPENDIX III.

This effect may be illustrated by an example. A transformer was kept in a tank of heated oil, the temperature of which was kept between 110° and 140° C. Readings of its loss were taken occasionally as below, the magnetisation being the same in all cases, the current being applied only at the time and for the purpose of the test.

This test has not yet been in progress long enough to show the slow rise very clearly.

	Watts.	
On immersion	33·13	Jan. 1, 1895.
After 20 minutes	32·19	
,, 40 ,,	32·1	
,, 1 hour	32·0	
,, 1 ,, 20 minutes	32·0	
,, 2 hours 30 ,,	31·54	
,, 24 ,,	28·88	
,, 2 days	29·6	
,, 3 ,,	30·67	
,, 4 ,,	31·5	
,, 6 ,,	36·0	
,, 7 ,,	33·6	
,, 8 ,,	36·6	
,, 9 ,,	32·6	
,, 18 ,,	32·9	
,, 29 ,,	35·9	Jan. 29, 1895.

Presents, January 17, 1895.

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